captured from Hayden Valley sites exhibited growth rate characteristics similar to those found in the Yellowstone River, but fish from Antelope Creek had lengths expected from a small headwater population (Figure 10).

For the fourth consecutive year, we sampled four locations in the Gibbon River between Gibbon Meadows and Madison Junction. The principal objective of this study was to monitor construction impacts to the stream during the Madison-to-Norris road reconstruction project. In addition to widening the existing road to meet current standards, several road kilometers are to be removed, and a new reroute and bridge over the Gibbon River built. Thus, the potential for increased sediment input into the stream and associated habitat degradation is very high. More importantly, this road removal portion of the project represents one of the first attempts by the park to restore a section of stream channel that has previously been altered by historic road building. Although most of the Gibbon River was originally barren of fish, the sections downstream from Gibbon Falls (Tuff Cliffs and Canyon Creek sample areas) historically contained westslope cutthroat trout and the riverine form of grayling. Westslope cutthroat trout have apparently been eliminated from

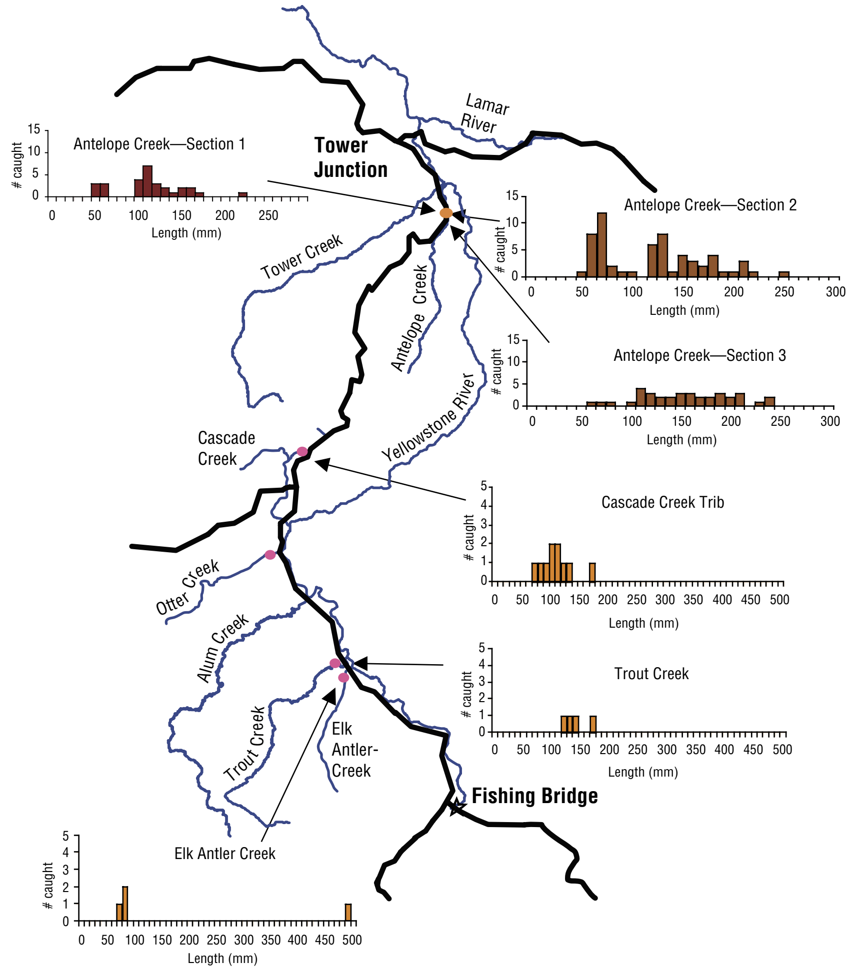

Figure 10. Length-frequencies distributions of Yellowstone cutthroat trout at sampling sites associated with road reconstruction activities along the Yellowstone River and several of its tributaries in 2003.

NPS fisheries crew, led by Dan Mahony, conducting an electrofishing survey of Slough Creek.

Yellowstone cutthroat trout from LeHardys Rapids, Yellowstone River.

the Gibbon River, but grayling are occasionally captured. Therefore, a secondary objective of our study was to document the responses of the few grayling that may reside in the lower sections of the stream to construction activities. Each year, brown trout were the most common fish collected at each sample area and the only species captured in the Tanker Curve section. During the past several low water years, estimated brown trout abundance averaged from 400 to 800 fish per kilometer. Rainbow trout were only captured downstream from Gibbon Falls; several dozen individuals sampled in 2003 were longer than 450 mm. Although no grayling were captured during 2002, the four individuals caught in 2003 represented the highest number captured in three years. Although this represents an encouraging trend, the widespread high density of brown trout probably contributes to the rarity of native grayling in its historical range in the Gibbon River watershed.

Surveys for Fish Health

In 2003, the Aquatics Section continued to participate in the U.S. Fish and Wildlife Service National Fish Health Survey to monitor the physical health of sampled fish populations that had not yet had a population level health diagnosis. According to the established survey protocols, a subsample of fish collected by fishery personnel were lethally sampled and examined for a variety of parasitic infections and bacterial and viral diseases. In 2003, 40 brook trout and 8 rainbow–cutthroat trout hybrids from Middle Creek (Shoshone River) were submitted for analyses. The fish health survey in Middle Creek is of interest not only as baseline information, but also because this stream is located in the headwaters of a large river basin that flows out of the park into Wyoming. Our sample sites are adjacent to a proposed construction area on the east side of the Sylvan Pass road reconstruction project, where the potential for spread of fish pathogens through construction activities is an important management consideration. Additionally in 2003, 35 cutthroat trout from the First Meadow area of Slough Creek were collected to complete the fish health survey of that basin, which was initiated in 2001. Final results about the health status of these populations are pending.

Genetics Surveys

With the non-lethal analysis techniques now available, extensive genetic testing of small or other at-risk fish populations is now possible. As described above for Fan Creek westslope cutthroat trout, continued genetic analyses are necessary to detect changes in a population that may prevent preservation of native trout genes. In addition to the new samples collected from 135 suspected westslope cutthroats in the Fan Creek watershed, fishery personnel also obtained fin tissue samples from Slough Creek ($N = 62$) and Bacon Rind Creek ($N = 25$). There is a high probability that non-native rainbow trout have interbred with native cutthroat at these sites.

With the non-lethal analysis techniques now available, extensive genetic testing of small or other at-risk fish populations is now possible.

Fin clips for genetic analyses were also obtained from Arctic grayling caught during the Gibbon River surveys. Although local grayling populations have low genetic variability, we are attempting to collect enough samples to examine whether there is a genetic difference between Grebe Lake grayling and those fish collected in downstream areas that are presumed to be fluvial grayling. Also, the Volunteer Flyfishing Program collected more than 100 additional genetic samples. Cutthroat trout were sampled in Lamar River, lower Pebble Creek, and Beula Lake, which are waters with known or suspected areas of hybridization. Individual genetic analyses of these fish will assist in determining the distribution of hybridization in these native fish populations.

Invasive Aquatic Exotic Species Threaten the Park

In addition to the parasite that causes whirling disease, Yellowstone National Park aquatic systems have been invaded by the New Zealand mudsnail (*Potamopyrgus antipodarum*). Mudsnails are extremely small (about 4–5 mm long) and highly prolific.[22] First found in the park in 1994, mudsnails now occupy the Firehole, Gibbon, Madison, and Gardner rivers, Polecat Creek, and likely others. Recent research indicates that these animals have been outcompeting and displacing native invertebrates. Dr. Billie Kerans at Montana State University reported that mudsnails comprised 25–50% of macroinvertebrates in the Gibbon and Madison rivers, and that fewer native mayflies, stoneflies, and caddisflies occurred in areas occupied by mudsnails.[23] The effect of these invaders on fish is unknown, but recent research indicates that mudsnails can pass completely through the gut of a fish unharmed while offering no nutritional value.

It would be nice to think that the waters of Yellowstone National Park could remain in a relatively pristine condition for future generations to enjoy, but this will not be the case without changes to the way we manage the movement of equipment, boats, and other gear among waters in our region. Presently, invasive exotic aquatic species occur in streams, rivers, and lakes (both near the coasts and inland) all across the United States.[24] While we may never know exactly how the parasite that causes whirling disease and the New Zealand mudsnail were introduced to the park, anglers can help prevent the additional spread of these animals, or of the many other invasive exotic species approaching our boundaries (e.g., zebra mussels, Eurasian watermilfoil, round goby).

Anglers should thoroughly clean all mud, plants, and debris from fishing equipment, and inspect footwear before leaving the angling site. We also recommend treating waders and boots with a 10% bleach solution. Boaters entering the park must completely remove plant material or any other debris from trailers and boat hulls; bilge areas and livewells must be thoroughly drained and likewise cleared of debris. The entire boat should be cleaned with hot (higher than 140°F) water and allowed to dry for several days. Boat transport is a primary method by which harmful animals are moving among waters in our country. Only through actions like these will we be able to stop the additional spread of invasive exotics.

Long-term Water Quality Monitoring

Water quality monitoring continued through 2003 at our 12 established stations on major river basins throughout Yellowstone National Park (Figure 1). Each site was visited once every two weeks, with sampling days being randomly selected. A multiparameter probe was used to collect water temperature, dissolved oxygen (DO), pH, specific conductance, and turbidity. Water samples were also collected at each location for total suspended solids (TSS) and volatile suspended solids analysis.

During 2003, most parameters varied considerably within and between sites

Anglers should thoroughly clean all mud, plants, and debris from fishing equipment, and inspect footwear before leaving the angling site.

Jeff Arnold, NPS aquatic ecologist, collecting macroinvertebrates from Bacon Rind Creek.

(Figure 11). Variations among water quality parameters were primarily due to diurnal cycles, high flows during spring snowmelt, rain events, seasonal temperature changes, altitude differences, and thermal influences that affected many streams. Highest mean temperatures of 15.9°C and 15.4°C occurred on the Firehole and Gardner rivers respectively, both of which are thermally influenced streams. Lowest mean temperature of 4.3°C occurred on upper Soda Butte Creek (range -0.2°C to 13.5°C). Highest mean DO concentration of 9.2 mg L^{-1} was recorded for both the Gibbon and Snake rivers with ranges of 7.7–12.8 mg L^{-1} and 7.5–10.7 mg L^{-1} respectively. The Firehole River exhibited the lowest average DO concentration of 8.0 mg L^{-1} (range 6.8–9.1 mg L^{-1}). Pelican Creek, a tributary to Yellowstone Lake with low velocity, exhibited the lowest recorded DO concentration of 6.3 mg/L on July 1.

Highest mean temperatures of 15.9°C and 15.4°C occurred on the Firehole and Gardner rivers respectively, both of which are thermally influenced streams.

Within-site variation in pH was quite low; variation was higher between sites (Figure 11). This was best illustrated in the Madison River drainage, which receives water from the Firehole and Gibbon rivers. Mean pH for the Firehole River was 8.3 (range 8.0–8.7). This was the highest mean value for all sites sampled with the exception of Gardner River, which also had a mean pH of 8.3. Conversely, the Gibbon River had the lowest mean pH at 6.8 (range 6.5–7.2). Values for specific conductance, turbidity, and TSS were highly seasonal and seemed to be directly related to river discharge. On average, specific conductance tended to be lowest during spring runoff when water was more plentiful, thus diluting the ionic concentration of the water. Spatial and temporal differences of specific conductance are best illustrated with three sites on the Yellowstone River (Figure 12). Specific conductance on the Yellowstone River at Fishing Bridge was least variable among all sites, and had the lowest mean value of 90.1 µS cm^{-1} (µS) (range 84–93 µS). By comparison, specific conductance at Corwin Springs was quite variable, with a mean of 216 µS (range 88–354 µS). The Gardner River exhibited the highest

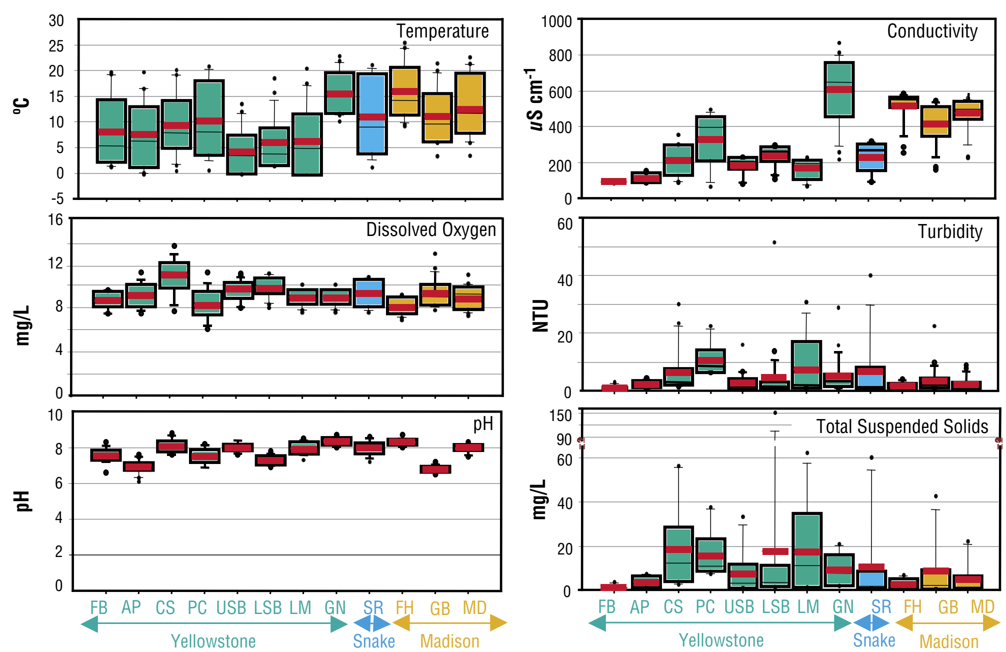

Figure 11. Box and whisker plot illustrating annual variation for selected parameters at each water quality location. Lower and upper portion of boxes represent the 25th and 75th percentile respectively; lower and upper black horizontal bars represent 10th and 90th percentile respectively. Outlying values are represented by black dots; means are indicated by solid red lines. Green, blue, and orange represent the Yellowstone, Snake, and Madison river basins, respectively (FB = Fishing Bridge, AP = Artist Point, CS = Corwin Springs, PC = Pelican Creek, USB = upper Soda Butte, LSB = lower Soda Butte, LM = Lamar River, GN= Gardner River, SR = Snake River, FH = Firehole River, GB = Gibbon River, and MD = Madison River).

mean value and was the most variable of all sites sampled for specific conductance, with a mean of 603 μS (range 217–866 μS). Overall, streams having high specific conductance were associated with drainages that had considerable thermal contributions, with Gardner, Firehole, Gibbon, and Madison rivers having the highest specific conductance of all sites sampled.

Turbidity and total suspended solids (TSS) were closely linked parameters (Figure 11). Higher turbidity values usually corresponded to spring runoff or localized precipitation events during summer months. Most sites had mean turbidity measurements below 10 nephlometric turbidity units (NTU), with the exception of Pelican Creek, which had a mean turbidity measurement of 10.8 NTU (range 6.4–22.4 NTU). The higher turbidity readings of Pelican Creek are most likely explained by higher phytoplankton concentrations in this slow moving stream. The Yellowstone River at Fishing Bridge had the lowest mean turbidity measurement of 1.0 NTUs (range 0.3–3.0 NTU). Not surprisingly, this site also had the lowest mean TSS concentration of 1.2 mg L^{-1} (range 0.5–3.5 mg/L). Lamar River exhibited the highest mean TSS of 21.2 mg L^{-1} (range 1.1–67.1 mg L^{-1}).

Limnology of Yellowstone Lake

A total of seven sites are now sampled periodically on Yellowstone Lake to document changes in basic limnological characteristics (two water quality sites were added in 2003 in the South Arm and Southeast Arm; Figure 2). The two new sites, sampled by the U.S. Fish and Wildlife Service from the mid-1970s through the early 1990s, were added to obtain a more comprehensive understanding of the limnology of Yellowstone Lake. Water quality data was collected every two weeks beginning in late May and continuing until mid-October. Water temperature, dissolved oxygen, pH, specific conductance, and turbidity measurements were recorded using a multiparameter probe. Water samples were also collected at each location for total suspended solids (TSS) and volatile suspended solids analysis.

SCOTT FAVROT

Jeff Arnold, NPS aquatic ecologist, collecting water quality information in Soda Butte Creek.

Water Quality Associated with Winter Use

During spring 2003, snowmelt runoff was sampled for concentrations of volatile organic compounds (VOC). VOCs in snowpack are most likely produced by incomplete combustion of gasoline from two-stroke snowmobiles. This study was initiated to determine if VOCs were present in snowmelt and, if so, whether there

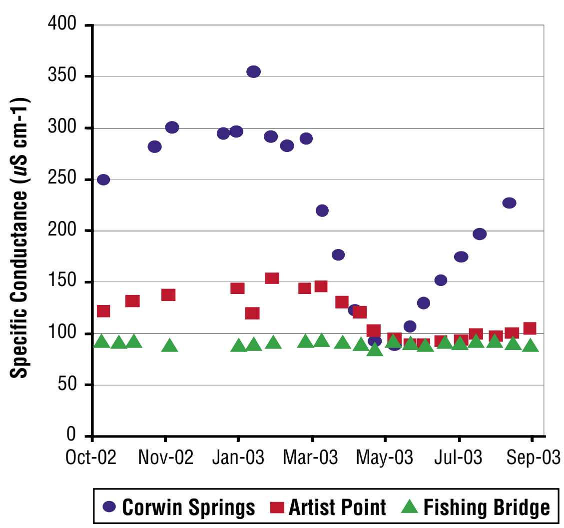

Figure 12. Specific conductance at three sites on the Yellowstone River illustrating temporal and spatial variation among sites. Note the low annual variability at the Fishing Bridge site versus high variability at the Corwin Springs site.

By investigating the type of aquatic organisms living within a selected stream reach, we can measure the current water quality condition of that stream.

was a possible link to snowmobile use within Yellowstone National Park. Sampling began after the 2002–2003 winter season, and went from March 15 through April 15. The study area was located within the road corridor between the West Entrance and Old Faithful. Three test sites were established within this area, with one site each in the vicinity of the West Entrance, Madison Junction, and Old Faithful. Selection of sample locations was based on the assumption that snowmelt was derived from snow that had originated from groomed roads. A fourth site was used as a control located in the Madison Junction vicinity on a small, intermittent stream. This sample location was approximately 100 yards from the road and flowed through an area that had been burned during the 1988 fires. Each site was visited nine times during the sampling period.

Sample analysis was conducted by the U.S. Geological Survey's laboratory in Denver, Colorado. Nine compounds within the VOC category were analyzed, including benzene, ethylbenzene, ethyl tert-butyl ether, isopropyl ether, m-xylene/p-xylene, methyl tert-butyl ether, o-xylene, tert-pentyl methyl ether, and toluene. Of the nine compounds tested, only five were detectable within any given sample (benzene, ethylbenzene, toluene, o-xylene, and m-xylene/p-xylene). Samples collected from the vicinity of Old Faithful and the West Entrance contained all five compounds during at least one sampling event. Highest levels for each compound were recorded near Old Faithful during early April 2003. This sample location drains much of the parking area utilized by visitors in the Old Faithful vicinity. The maximum recorded concentration for these five compounds were (units are µg L-1): benzene, 0.031; ethylbenzene, 0.27; toluene, 0.61; o-xylene, 0.69; and m-xylene/p-xylene, 1.45. All VOC compounds for the Madison Junction site were below detection levels, likely due to large volumes of snow melting off adjacent hillsides and diluting VOC concentrations in snowmelt. The control site did contain trace levels of toluene during six of the nine site visits. These results are similar to those of previous investigators, where trace levels of toluene were found in snowpack from off-road locations.[25] The origin of this chemical remains unknown, and further studies are needed to evaluate its source. All VOC concentration levels were well below the Environmental Protection Agency's level of toxicity to aquatic organisms.

JEFF ARNOLD

Stonefly from Soda Butte Creek.

Macroinvertebrate Monitoring

Aquatic macroinvertebrates were used as a bioassessment tool to evaluate the current condition of water resources. They are ideal organisms to use because they are long lived (one to three years), relatively immobile, and sensitive to environmental (i.e., chemical and physical) changes. Thus, by investigating the type of aquatic organisms living within a selected stream reach, we can measure the current water quality condition of that stream.

During fall 2002, the Aquatics Section worked in conjunction with the Greater Yellowstone Network (GRYN) to conduct aquatic macroinvertebrate sampling from selected streams within the GRYN's three National Park Service units: Bighorn Canyon National Recreation Area (BICA), Grand Teton National Park (GRTE), and Yellowstone National Park. This was done to supplement ongoing water quality monitoring and establish current inventories and distributional patterns of aquatic macroinvertebrate species.

In Yellowstone National Park, sampling

locations were primarily selected based upon proximity to various road construction projects that were expected to begin within three years. Streams (and the number of sites) selected for sampling near proposed road construction projects were: Obsidian Creek (4), Antelope Creek (3), Middle Creek (3), and Gardner River (3) (Figure 1). The objective was to obtain baseline information regarding aquatic invertebrate communities prior to road construction. This, and subsequent data, will be used to determine impacts on water resources within areas of major road construction. Additional criteria for selection of invertebrate sample locations within the three GRYN parks included threats from mining waste, grazing activities, and proximity to campgrounds. Some sites were also selected in areas of thermal inputs to ascertain community composition of invertebrates living in waters with naturally occurring thermal and chemical stressors.

To account for spatial and temporal variability of benthic macroinvertebrate communities from each park, 40 sites from 19 streams were sampled using a 500-m surber net. A total of 232 taxa (species groups) were identified from the three parks—70 from BICA and 165 each from GRTE and Yellowstone National Park. The modified Hilsenhoff biotic index (HBI) was calculated for each site. This index evaluates tolerance levels of benthic macroinvertebrates to organic pollutants, thermal regimes, and dissolved oxygen concentrations. The HBI rates each sample based on a scale of 0–10, with the lowest values representing excellent water quality condition and successively higher values representing a more degraded condition. From the 40 sites sampled within the three parks, 31 ranked between good and excellent, 7 ranked poor to fair, and 2 ranked very poor (Figure 13). Because of the abundant thermal features affecting Yellowstone National Park's surface waters, using contemporary methods to evaluate these waters is particularly challenging. Thermally influenced surface waters have naturally high temperatures, low dissolved oxygen concentrations, and higher dissolved solutes than streams lacking thermal inputs. The HBI ranked five sample locations within Yellowstone as being fair to very poor.

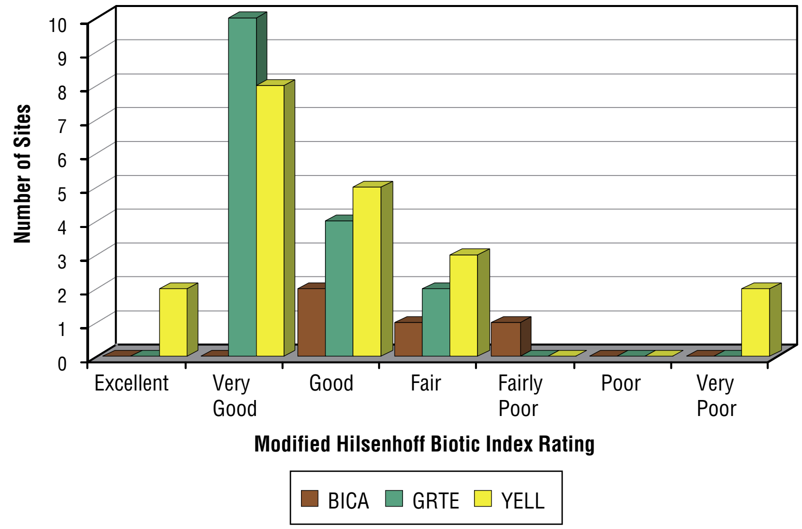

Figure 13. Stream ranking using the modified Hilsenhoff biotic index based on macroinvertebrate communities of streams in Greater Yellowstone Network parks, including Bighorn Canyon National Recreation Area (BICA), Grand Teton National Park (GRTE), and Yellowstone National Park (YELL).

All of these sample locations were in areas that receive heavy to moderate thermal inputs, thus affecting the aquatic communities residing within those waters. More sampling is needed to evaluate aquatic communities that occur naturally within thermally influenced streams.

During 2003, benthic macroinvertebrate sampling continued for many streams in Yellowstone National Park. Sixteen stream segments were sampled in areas where major road construction is anticipated during the next two years (Figure 1). In addition, 11 sites were sampled in the northwestern portion of the park. Nine sites were sampled within the Fan and Specimen creek drainages, with six sites sampled on Fan Creek and one set of samples each collected from Crescent, Sedge, and Crag lakes. These samples were collected as part of the westslope cutthroat trout restoration project. Invertebrate samples will be used to evaluate the current condition of streams within the Fan and Specimen creek drainages, and to provide current inventory information and distribution patterns of aquatic invertebrates living within those drainages prior to any fish restoration attempt there. Also, two sites were sampled on Bacon Rind Creek in response to potential impacts from a fire retardant spill that occurred during September. These samples will be used to evaluate impacts to water quality as a result of that spill.

Impacts of the New Zealand Mudsnail in Waters of Yellowstone National Park

Adapted from publications
by B. L. Kerans, D. C. Richards, and R. O. Hall Jr.

The New Zealand mudsnail (*Potamopyrgus antipodarum)* was first discovered in the western United States in the Snake River, Idaho, during the 1980s. It is now rapidly spreading and has become established in rivers in seven western states and three national parks, including Yellowstone. It is a parthenogenic livebearer with high reproductive potential, meaning that when conditions are right, the adult mudsnails can produce many offspring throughout the year without a mate. In fact, with an average of 50 offspring produced per snail, through six generations in a year, a single snail could result in the production of over 300 million new snails![1] The New Zealand mudsnail often reaches densities greater than 100,000/m^2 in suitable habitat and has been reported to approach densities as high as 750,000/m^2 in sections of rivers in Yellowstone National Park. Especially favored by these invaders are the unique, geothermally influenced waters of the park. Frequently, the mudsnails will comprise over 95% of the invertebrate biomass in a river.

Research has documented decreases in native macroinvertebrate populations in several rivers where the New Zealand mudsnail has invaded. In the Gibbon and Madison rivers, about a quarter to over half the macroinvertebrate community has consisted of mudsnails.[2] Also, a negative correlation was found between the numbers of native mayflies, stoneflies, and caddisflies, species that are an important component of the diets of salmonids and several bird species in Yellowstone National Park. The negative interactions between mudsnails and the native macroinvertebrates could be propagated up the food web and negatively effect these important consumer populations.

DAN GUSTAFSON

Even if they are eaten, mudsnails are difficult to digest because they have a hard shell and protective cover (called an operculum) that seals them from their environment. Mudsnails have been known to pass completely through the gut of a fish unharmed! Certainly their lack of nutritional value and ability to outcompete and displace native aquatic insect communities makes them a serious threat to the waters of Yellowstone.

New Zealand mudsnails have also been shown to drastically alter primary production in some streams. Recent research has shown these invaders are consuming most of the primary production (the dominant food source) in the Firehole River and Polecat Creek.[3] The food resources are being taken up by the invasive snails rather than by the native macroinvertebrates.

In the Greater Yellowstone Ecosystem, the New Zealand mudsnail currently exists in the Firehole, Gardner, Gibbon,

DAVID RICHARDS

New Zealand mudsnails can outcompete native macroinvertebrates and consume most of the primary production of Yellowstone National Park streams.

Decreases in native macroinvertebrates have been noted in streams where New Zealand mudsnails have invaded.

With an average of 50 offspring produced per snail, through six generations in a year, a single snail could result in the production of over 300 million new snails!

Madison, and Yellowstone rivers and Polecat and Nez Perce creeks (Figure 14). The invasion of this exotic species has generated much concern about the potential impacts it may have on native species, fisheries, and aquatic ecosystems in the western United States. Its spread into new systems is considered to be primarily human caused. To prevent additional spread of this harmful exotic species, all of us that enjoy the waters of Yellowstone have the serious responsibility to make sure all gear, waders, and other equipment are free of mud and debris, and we are not transporting mudsnails among waters in this region.

1. Richards, D. C. 2002. The New Zealand mudsnail invades the western United States. *Aquatic Nuisance Species Digest* 4:42–44.
2. Kerans, B. L., M. F. Dybdahl, M. M. Gangloff, and J. E. Jannot. 2004. *Potamopyrgus antipodarum*: distribution, abundance and effects on native macroinvertebrates in the Greater Yellowstone Ecosystem. *Journal of the North American Benthological Society* (In review).
3. Hall, R. O. Jr., J. L. Tank, and M. F. Dybdahl. 2003. Exotic snails dominate nitrogen and carbon cycling in a highly productive stream. *Frontiers in Ecology and the Environment* 1:407–411.

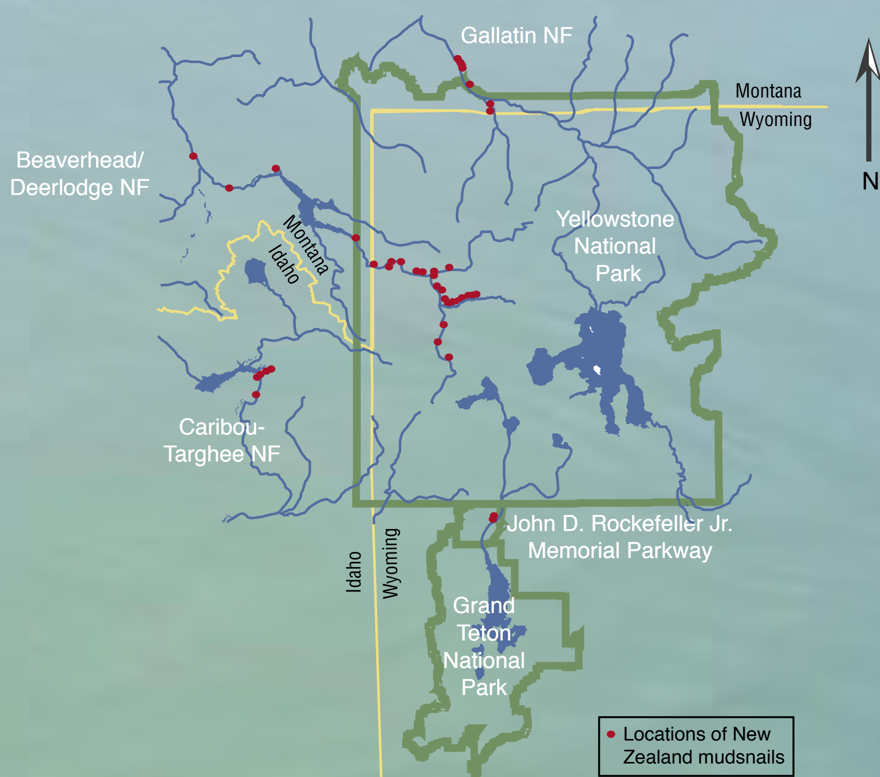

Figure 14. Locations of New Zealand mudsnails in the Greater Yellowstone Ecosystem.

Angling in the Park

Trends from the Volunteer Angler Report Cards

The more than three million visitors to Yellowstone National Park in 2003 represented another all-time high. Angling remains a popular visitor pastime; over 54,000 special use fishing permits were issued in 2003. A volunteer angler response (VAR) card is provided with each fishing permit, providing anglers the opportunity to report where they fish, the species and size of fish caught, and their satisfaction with the fishing experience. There has been a response rate of almost 4,000 angler outings per year in recent years from the VAR cards.

Native cutthroat trout remained the most sought-after and caught fish species, making up 59% of the total catch.

Park fisheries managers use the information provided by VAR cards to get an overview of fish population dynamics and angler attitudes toward the fisheries resource throughout the waters of Yellowstone National Park. Data from 2001 and 2002 indicate that anglers fished 2.75 hours per day during typical fishing trips in the park. Single-day anglers reported catching at least one fish 78% of the time, and on average landed almost one (0.89) fish per each hour of fishing.

TIMOTHY BYWATER

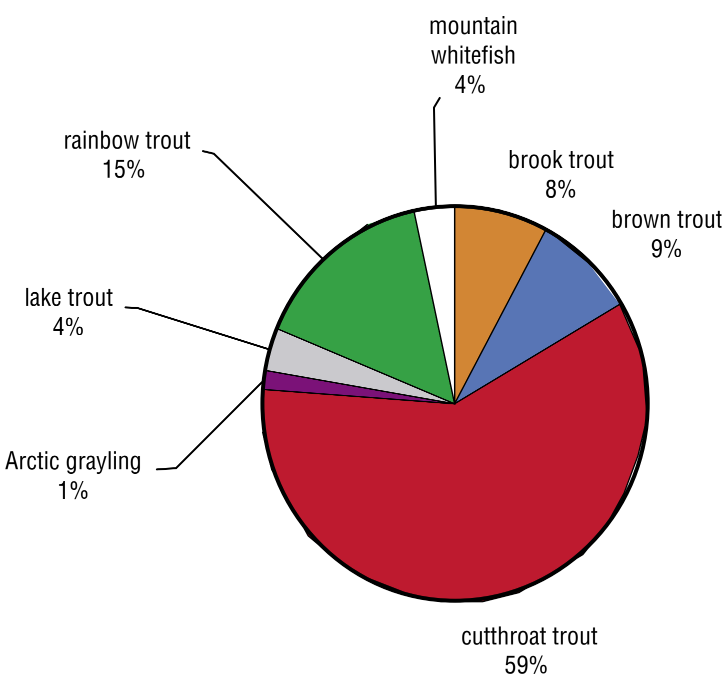

Figure 15. Total angler reported catch by percent of fish species in Yellowstone National Park in 2001–02.

Native cutthroat trout remained the most sought-after and caught fish species, making up 59% of the total catch, followed distantly by rainbow trout 15%, brown trout 9%, brook trout 8%, whitefish and lake trout each 4%, and grayling 1% (Figure 15). The majority of anglers were satisfied with their overall fishing experience (75%), the numbers of fish caught (62%), and the size of the fish caught (68%). Anglers typically reported on many fishable waters in the park; their observations can be the first line of information toward identifying potential fisheries related problems.

Yellowstone Lake remains the most popular destination for anglers that come to the park; an estimated 13,685 anglers fished Yellowstone Lake in 2002. The angler catch per effort for cutthroat trout in Yellowstone Lake has decreased for the past four years, and is now at its lowest level since summaries of VAR cards were compiled in 1979 (Figure 16). Average total length has increased annually for seven years and is also at an extreme, its highest level since 1979. These changes to the fishery coincide with the discovery and subsequent expansion of lake trout since the mid-1990s. Angler catch per effort of lake trout was at its all-time high in 2002; however, lake trout are still caught at a much lower rate than cutthroat trout.

Slough Creek has been a popular destination for anglers wishing to catch large numbers and sizes of the native Yellowstone cutthroat trout. Slough Creek can be divided into two distinct segments of meandering stream, separated by a narrow canyon and steep cascade that is

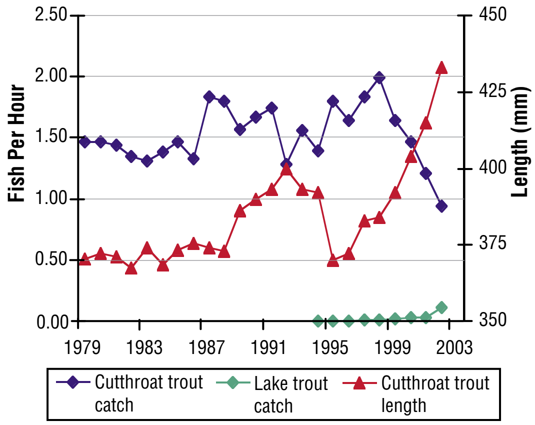

Figure 16. In Yellowstone Lake, angler-reported catch rate for Yellowstone cutthroat trout declined for the fourth year in a row during 2002. Average length of angler-caught cutthroat trout increased for the seventh year in a row, and is at its highest since 1979.

Opening day on the Yellowstone River.

impassable for fish. Anglers fishing the upstream section of Slough Creek catch cutthroat trout at twice the rate of those fishing the downstream section. However, the catch rate of fish in the upper section has been on a gradual downward trend (Figure 17). Anglers reported that rainbow trout are in both sections; however, they were more successful at catching rainbow trout in the downstream section. The length of trout caught in Slough Creek has not changed much in 35 years. Average length of a cutthroat trout caught in Slough Creek during 2002 was 315 mm (12.4 inches), while the average rainbow trout caught was 260 mm (10.3 inches).

Another noteworthy trend is the declining angler catch rate of Yellowstone cutthroat trout in Pelican Creek. Pelican Creek is a tributary to Yellowstone Lake and has historically been a destination for anglers seeking adfluvial "lake run" cutthroat trout. Angler catch rate of cutthroat trout in Pelican Creek is currently just a fraction ($^1/_3$) of what it was in the 1980s (Figure 18). The reduced catch rate in Pelican Creek is likely due to loss of cutthroat trout fry due to whirling disease and predation by lake trout in Yellowstone Lake.

Fisheries managers will continue to use the VAR cards as a tool to gauge fish population trends, use of waters, and visitor enjoyment of the tremendous fishing opportunities that remain in Yellowstone National Park.

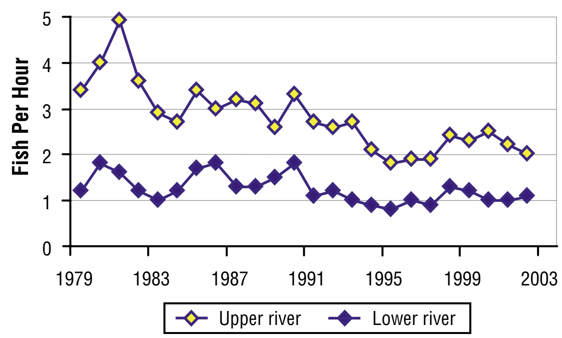

Figure 17. Angler-reported catch rates of Yellowstone cutthroat trout in Slough Creek upstream and downstream of the cascade near the campground. Catch rates of Yellowstone cutthroat trout are slowly declining in the upper river reach.

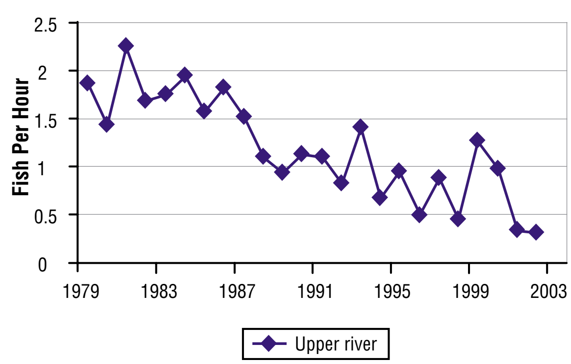

Figure 18. Declining trend of angler-reported success for Yellowstone cutthroat trout in Pelican Creek, a tributary to Yellowstone Lake.

Public Involvement

Yellowstone Volunteer Flyfishing Program

A program was established to incorporate flyfishing volunteers and use catch-and-release angling as a capture technique.

Much of the effort by Yellowstone's fisheries staff in recent years has been redirected at emerging crises such as lake trout removal and whirling disease, yet there are a multitude of other fisheries issues and questions to be addressed. There are an estimated 2,650 miles of streams and 150 lakes in the park, with surface waters covering 5% of Yellowstone's 2.2 million total acres. Realizing that NPS staff could not address many issues, a program was established to incorporate flyfishing volunteers and use catch-and-release angling as a capture technique to gather biological information on fish populations located throughout the park. In 2003, the Volunteer Flyfishing Program was coordinated by Dr. Timothy Bywater, an avid flyfisherman and long-time supporter and promoter of Yellowstone's fisheries. Projects addressed included:

- determination of the range of hybridized Yellowstone cutthroat trout in the Lamar River and its major tributaries;
- documentation of the Beula Lake fishery; and
- documentation of the status and movement patterns of grayling originating in Grebe and Wolf lakes of the Gibbon River system.

Under this incredibly successful program, 74 volunteer anglers from across the United States traveled to the park and participated as an active component of the Aquatics Section. Volunteers experienced many fisheries issues first hand. The biological data collected will assist in our understanding of the park's fisheries status.

TIM BYWATER

Long-term Volunteer Assistance

The Aquatics Section recruits long-term (more than 12-week) volunteers from the Student Conservation Association and other sources (see Appendix ii). Volunteers stay in park housing at Lake and work a full-time schedule similar to paid NPS seasonal staff. All aspects of the Aquatics Section are affected and greatly benefit from both long- and short-term volunteer support. In 2003, a total of 98 volunteers dedicated 4,041 hours to Aquatics Section activities.

Educational Programs

Aquatics Section staff continued to provide a variety of short-term educational programs for visiting schools and other interested groups. Of special note in 2003 was the incorporation of six high school scholars from St. Steven & St. Agnes School, Washington, D.C., and their leader, Mansir Petrie. This group spent over a week in the park's interior working closely with NPS fisheries biologists, primarily on tributary spawning migration trap operations.

Collaborative Research

The Yellowstone Center for Resources through the Aquatics Section has provided direct and indirect support for collaborative research with scientists at other institutions, primarily universities. The studies address some of the most pressing issues faced by NPS biologists and other regional managers of aquatic systems.

Projects by Graduate Students

Graduate Student: Silvia Murcia (Doctor of Philosophy candidate). *Committee Co-Chairs:* Dr. Todd Koel and Dr. Billie Kerans, Department of Ecology, Montana State University. *Title:* Relating *Myxobolus cerebralis* infection in native Yellowstone cutthroat trout (*Oncorhyncus clarki bouvieri)* with environmental gradients at three spawning tributaries to Yellowstone Lake in Yellowstone National Park.

Graduate Student: Lusha Tronstad (Doctor of Philosophy candidate). *Committee Chair:* Dr. Robert Hall, Department of Zoology and Physiology, University of Wyoming. *Title:* Decline in nitrogen transported by Yellowstone cutthroat trout spawning migrations.

Graduate Student: Carrie Brooke (Master of Science candidate). *Committee Chair:* Dr. Al Zale, U.S. Geological Survey Cooperative Fisheries Research Unit and Department of Ecology, Montana State University. *Title:* Life history strategies of native westslope cutthroat trout in Fan Creek, Yellowstone National Park.

The NPS Cutthroat *on the West Thumb of Yellowstone Lake.*

Researchers Dave Lovalvo (left) and Jim Maki (center) prepare a remotely operated vehicle for deployment, with assistance from Erika Thompson.

Other Research and Collaboration

The Aquatics Section continues to support a variety of other research projects in Yellowstone National Park. Of special mention is the research by the Great Lakes WATER Institute, University of Wisconsin at Milwaukee; Marquette University, Milwaukee; the U.S. Geological Survey, Denver; and Eastern Oceanics, Connecticut. Scientists from these institutions set up a laboratory at Lake and outfitted the NPS Aquatics Section's boat, the *Cutthroat,* with a submersible remotely operated vehicle, or ROV, to study the physical, chemical, and biological characteristics of Yellowstone Lake, especially associated with hydrothermal vent systems.

A limited number of Yellowstone cutthroat trout gametes were collected by Montana Department of Fish, Wildlife and Parks from McBride Lake (Slough Creek drainage) and by Wyoming Game and Fish Department from the Yellowstone River at LeHardys Rapids. In all cases, gametes were used for enhancement of native cutthroat broodstock and restoration activities in Montana and Wyoming. Each year, age-zero Yellowstone cutthroat trout from the broodstock (LeHardys Rapids origin) in Wyoming are returned to the park for whirling disease exposure studies.

Acknowledgments

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Many additional dedicated individuals from within Yellowstone National Park have contributed to the success of Aquatics Section activities; unfortunately we cannot mention them all here. However, we would like to especially thank Dave Hill, Earl McKinney, Susan Ross, Bruce Sefton, Melinda Sefton, Art Truman, Mark Vallie, Lynn Webb, and Dave Whaley from Lake Maintenance; Rick Fey and Kim West from Lake District Rangers; and Wally Wines from Ranger Corral Operations.

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- Federal Highway Administration, Park Roads and Parkways Program
- Greater Yellowstone Coordinating Committee
- National Park Service, Natural Resource Challenge, Natural Resource Preservation Program
- National Park Service, Recreational Fee Demonstration Program
- National Park Service, Inventory and Monitoring Program, Vital Signs Monitoring Program
- National Partnership for the Management of Wild and Native Coldwater Fisheries, Whirling Disease Initiative
- Whirling Disease Foundation
- Yellowstone Association
- Yellowstone Park Foundation

Special thanks to Dr. Charles Peterson, Idaho State University, for conducting amphibian surveys, and to Dr. Cheryl Jaworowski, Yellowstone Center for Resources, for conducting geological surveys associated with potential westslope cutthroat trout restoration efforts at Fan Creek.

We thank the many volunteers who have dedicated their time and also a great deal of other expense to our Aquatics Section, as without them, much of what we do in our programs would not be possible.

Flyfishing anglers from Trout Unlimited, Fly Fishing Federation, Henry's Fork Foundation, and many other organizations in the region and throughout the United States contributed hundreds of hours of time and costs associated with travel to our Volunteer Flyfishing Program; for that we are extremely grateful.

Through collaboration with the U.S. Fish and Wildlife Service's Bozeman Fish Health Laboratory, the U.S. Geological Survey's Western Fisheries Research Center in Seattle, Washington, the Department of Ecology at Montana State University, the Montana Department of Fish, Wildlife and Parks, and the Wyoming Game and Fish Department, we have been able to learn a great deal about whirling disease in the Yellowstone Lake basin. We thank all the individuals from these agencies for their kind support.

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BRIAN ERTEL

NPS Supervisory Fisheries Biologist Dr. Todd Koel with Sammy *and* Ethan*, packing into Thorofare Creek, October 2003.*

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Appendices

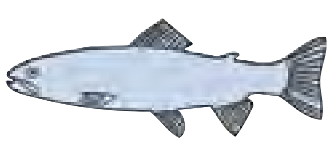
Appendix i. Fish Species List

Native (N) and introduced (non-native or exotic, I) fish species and subspecies known to exist in Yellowstone National Park waters including the upper Missouri (Missouri, Madison, and Gallatin rivers), Snake River (Snake), and Yellowstone River (Yell R.) drainages.

Family	Common Name	Scientific Name	Status	Missouri	Snake	Yell R.
Salmonidae	Yellowstone cutthroat trout	*Oncorhynchus clarki bouvieri*	Native	I	I	N
	westslope cutthroat trout	*Oncorhynchus clarki lewisi*	Native	N		
	finespotted Snake River cutthroat trout	*Oncorhynchus clarki behnkei*	Native		N	
	rainbow trout	*Oncorhynchus mykiss*	Non-native	I	I	I
	mountain whitefish	*Prosopium williamsoni*	Native	N	N	N
	brown trout	*Salmo trutta*	Exotic	I	I	I
	eastern brook trout	*Salvelinus fontinalis*	Non-native	I	I	I
	lake trout	*Salvelinus namaycush*	Non-native		I	I
	Montana grayling	*Thymallus arcticus montanus*	Native	N		I
Catostomidae	Utah sucker	*Catostomus ardens*	Native		N	
	longnose sucker	*Catostomus catostomus*	Native			N
	mountain sucker	*Catostomus platyrhynchus*	Native	N	N	N
Cyprinidae	lake chub	*Couesius plumbeus*	Non-native			I
	Utah chub	*Gila atraria*	Native	I	N	
	longnose dace	*Rhinichthys cataractae*	Native	N	N	N
	speckled dace	*Rhinichthys osculus*	Native		N	
	redside shiner	*Richardsonius balteatus*	Native		N	I
Cottidae	mottled sculpin	*Cottus bairdi*	Native	N	N	N

Appendix ii. Long-term Volunteers, 2003

Name	Period of Involvement	Hours
Christianson, Collin	08/10/2003–09/24/2003	240
Harris, Jessica	08/10/2003–11/01/2003	480
Hurst, Phillip	05/18/2003–08/09/2003	480
Metsky, Jeffrey	08/10/2003–11/01/2003	480
Reider, John	05/18/2003–08/09/2003	480
Schamberry, Nicole	05/18/2003–08/09/2003	480
Selvage, Nina	07/18/2003–08/21/2003	200



Appendix iii. Seasonal Staff, 2003

Name	Period of Involvement
Bywater, Timothy	05/18/2003–09/07/2003
Dixon, Chris	05/04/2003–11/01/2003
Facendola, Joseph	05/11/2003–11/01/2003
Farias, Rene	05/04/2003–09/20/2003
Favrot, Scott	05/04/2003–12/31/2003
Keep, Shane	05/04/2003–11/01/2003
Legere, Nicole	05/25/2003–08/26/2003
Mintkeski, Tyler	05/11/2003–09/12/2003
Olszewski, Brad	05/18/2003–08/29/2003
Rowdon, Barb	01/01/2003–12/31/2003
Ruhl, Mike	02/18/2003–05/16/2003
Slattery, Kelly	05/25/2003–08/22/2003
Sigler, Stacey	05/11/2003–11/01/2003
Steed, Amber	05/04/2003–10/10/2003
Vonderohe, Gary	05/04/2003–11/01/2003
Wethington, Don	05/04/2003–11/01/2003
White, Davina	05/04/2003–11/01/2003

Arctic grayling.